

An Apparatus for Launching and Recovering a Vessel and Related Method

Field & Background

5 The present invention relates to an apparatus for launching and recovering a vessel and a corresponding method.

10 The conventional method of launching a small boat (hereinafter boat) from a mother vessel typically uses a system comprising a set of passive rollers and a winch. Human intervention is required to manually unhook the boat from a winch hook, and thereafter allowing the boat to slow roll down a stern ramp of the mother vessel, with aid of the passive rollers, into the sea. Recovery of the boat correspondingly requires the floating boat to first be aligned with the centre line of the stern ramp, which is done by adjusting the control rudder and related propulsion of the boat, before manually hooking the aligned boat to the winch hook. The boat is then subsequently pulled up into the mother vessel using the winch.

20 However, under severe sea conditions, launch or recovery of the boat via the conventional method is dangerous and difficult due to the risks involved, such as possibility of the launch/recovery personnel falling into the sea due to strong tidal waves that rock the mother vessel, the undesirable need to hook up the winch to the vessel to be recovered under strong sea conditions, and other related safety issues (e.g. risk of injury to the launch/recovery personnel when hooking up the winch). Moreover, the conventional method is only suitable for launch/recovery of manned vessels, but not unmanned vessels (e.g. unmanned surface vehicles (USV)).

30 One object of the present invention is therefore to address at least one of the problems of the prior art and/or to provide a choice that is useful in the art, in terms of enabling a safe and effective way of launching and recovering vessels.

Summary

35 According to a 1st aspect of the invention, there is provided an apparatus for launching and/or recovering a vessel. The apparatus comprises a plurality of drive units arranged along a launch and recovery platform, each drive unit

having a set of guide members for supporting the vessel's hull, and an actuator configured to actuate the respective sets of guide members to cause the hull to move progressively along the platform for launch or recovery of the vessel. The platform is preferably configured to be inclined relative to a horizontal plane of a base.

Advantages of the proposed apparatus include not requiring human intervention for recovery/launch of the vessel to guide the vessel up the platform, and may thus be suitable to launch/recover unmanned boats such as unmanned-surface-vehicles (USVs). Further, the apparatus is advantageously configured with features that allow dynamic adjustability to various hull forms of different vessels (to be recovered or launched). Importantly, the proposed system flexibly enables adaptive adjustment to be made to the system for ease of launch/recovery of a boat of a specific hull form, without the need to specially install custom-made systems for those purposes. Moreover, the apparatus also enables rapid launch and recovery of vessels of approximately 11 metres long from a mother vessel, in a sea state of level-3. As a result, this mitigates risk of launch/recovery personnel falling into the sea due to strong tidal waves, which thus improves the overall safety of such vessel launching or recovery operations.

Preferably, the base may be configured to be mounted to a mother vessel. Alternatively, the apparatus may further comprise a mother vessel, wherein the base is part of the mother vessel. Preferably, the apparatus may further comprise a pulling means which is removably attachable to the vessel to, in conjunction with the respective sets of actuated guide members, progressively move the vessel along the platform. More specifically, the pulling means may include a winch. Further preferably, each drive unit may comprise a plurality of side support members for supporting sides of the hull, the plurality of side support members being arranged adjacent to the set of guide members.

Particularly, each side support member may include at least one roller for engaging with the sides of the hull, and a pivotable arm configured to support the at least one roller, the at least one roller configured to be free-rolling. Preferably, a position of the pivotable arm may be adjustable to enable the at

least one roller to engage with a respective shaped section of the hull. More preferably, the pivotable arm may be adjustable to move between an angle of 5° and 40° relative to the base of each drive unit. In addition, the apparatus may further comprise an auxiliary arm for adjusting the position of the pivotable arm, the auxiliary arm being of a fixed length. Yet preferably, each drive unit may further comprise at least one free-rolling guide member which may be interleaved between the set of guide members.

The apparatus may also further comprise a set of entry guide rollers for guiding the vessel towards or away from at least some of the plurality of drive units to enable recovery or launch of the vessel, and may be arranged to be near a first end of the platform at which the vessel is launched or recovered. Moreover, the apparatus may further comprise a support guide unit that is adjustable to support the bow section of the hull, and is arranged to be near an end of the platform opposite to the first end. Preferably, the support guide unit may include a pivotable arm configured to support at least one roller for engaging with the bow section, and the pivotable arm may be adjustable to move between an angle of 12° and 80° relative to the base of the support guide unit. Yet further, the set of guide members may include keel rollers. Further preferably, the platform may be configured to be inclined at an angle of approximately between 8° to 20°.

According to a 2nd aspect of the invention, there is provided a mother vessel for launching and/or recovering a vessel. The mother vessel comprises the apparatus according to the 1st aspect of the invention, wherein the apparatus is installed on a launch and recovery platform of the mother vessel, the platform being preferably configured to be inclined at an angle of approximately between 8° to 20° relative to a horizontal plane of the mother vessel.

According to a 3rd aspect of the invention, there is provided a method for launching and/or recovering a vessel using an apparatus. The apparatus includes a plurality of drive units arranged along a launch and recovery platform, the platform being preferably configured to be inclined relative to a horizontal plane of a base, each drive unit having a set of guide members for supporting the vessel's hull, and an actuator configured to actuate the respective sets of guide members. The method then comprises operating the actuator to actuate

the respective sets of guide members to cause the hull to move progressively along the platform for launch or recovery of the vessel.

5 Preferably, each drive unit may comprise a plurality of side support members for supporting sides of the hull, each side support member may include at least one roller, and a pivotable arm configured to support the at least one roller, the method may further comprise adjusting the pivotable arm to engage the at least one roller with a respective shaped section of the hull. Further preferably, the base may be configured to be mounted to a mother vessel. Alternatively, the
10 method may further comprise providing a mother vessel, wherein the base is part of the mother vessel.

According to a 4th aspect of the invention, there is provided an apparatus for launching and/or recovering a vessel. The apparatus comprises a launch and
15 recovery platform, the platform being inclined relative to a horizontal plane of a base, a plurality of support units arranged along the platform, each support unit having a set of side support guide members which are in an angularly adjustable arrangement with the base of the drive unit for supporting the sides of the vessel's hull, and launch and recovery device to cause the hull to move
20 progressively along the platform to be supported by the respective sets of adjusted side support guide members for launch or recovery of the vessel.

Preferably, each side support member may include at least one roller for engaging with the sides of the hull, and a pivotable arm configured to support
25 the at least one roller, the at least one roller configured to be free-rolling. More preferably, a position of the pivotable arm may be adjustable to enable the at least one roller to engage with a respective shaped section of the hull. Additionally, each support unit may further comprise a set of guide members which are configured to be free-rolling and arranged adjacent to the set of side
30 support guide members. Also, the launch and recovery device may include a winch.

It should be apparent that features relating to one aspect of the invention may also be applicable to the other aspects of the invention.

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These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

Brief Description of the Drawings

- 5 Embodiments of the invention are disclosed hereinafter with reference to the accompanying drawings, in which:
- Figure 1 is an isometric view of a launch and/or recovery system for vessels, according to a first embodiment of the invention;
- 10 Figures 2a and 2b depict a stern ramp on which the system of Figure 1 is installed, in which the ramp door of the stern ramp is fully opened in Figure 2a and fully closed in Figure 2b;
- Figure 3 shows an apparatus for launching and/or recovery vessel, in which the apparatus comprises the system of Figure 1 and the stern ramp of Figure 2;
- Figure 4 is an isometric view of a drive unit of the system of Figure 1;
- 15 Figure 5 is a side view of the drive unit of Figure 4;
- Figure 6 shows an exploded view of the drive unit of Figure 4;
- Figures 7a to 7f show magnified views of certain parts of the drive unit of Figure 4;
- Figure 8 shows a magnified view of a spring insert of the drive unit of Figure 4;
- 20 Figures 9a to 9e show different views of a worm gear assembly of the drive unit of Figure 4;
- Figures 10a to 10e show different views of a bevel gear assembly of the drive unit of Figure 4;
- Figure 10f show turning operations effected through using the bevel gear assembly of Figure 10e;
- 25 Figure 11 shows an adjustment key used for turning the bevel gear assembly of Figure 10;
- Figures 12a and 12b respectively show a side view along the length and a top view of the drive unit of Figure 4, while Figures 12c and 12d show magnified views of certain portions of the top view of Figure 12b;
- 30 Figure 13a shows the top view of the drive unit of Figure 4, and Figures 13b to 13d show different cross-sectional side views along the length of the same drive unit;
- Figures 14a to 14d show four maximum adjusted positions of the side guide wheels assembly of the drive unit of Figure 4;
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Figure 15 shows a plot of positions in the X and Z-axes through which the side guide wheels assembly of the drive unit of Figure 4 can be adjusted;

Figures 16a and 16b show respective back views of two hulls of different forms being supported by the system of Figure 1;

5 Figures 17a and 17b respectively show an isometric view and an exploded view of a support guide unit of the system of Figure 1;

Figures 18a to 18c show different views of the support guide unit of Figure 17a;

Figures 19a and 19b show respective front views of the bow heads of the two hulls of Figure 16a and 16b supported by the support guide unit of Figure 17a;

10 Figures 20a to 20e show different views of an entry guide rollers assembly of the system of Figure 1;

Figure 21a shows a side view of an approaching vessel contacting with a first drive unit of the system of Figure 1 installed on the stern ramp;

15 Figure 21b shows a side view of the vessel of Figure 21a progressively advancing up the stern ramp;

Figure 22a and 22b show movable adjustment of the drive units, each of Figure 4, in a longitudinal Y-axis direction along the stern ramp;

Figure 23 shows an isometric view of a recovered vessel resting on the system of Figure 1;

20 Figures 24a and 24b respectively show a side view and a bottom view of the recovered vessel of Figure 23 resting on the system of Figure 1;

Figure 25 show another isometric view of the recovered vessel of Figure 23 resting on the system of Figure 1;

25 Figure 26 shows an isometric view of a lite-version of the drive unit of Figure 4, according to a second embodiment;

Figure 27 shows an exploded view of the drive unit of Figure 26;

30 Figure 28a shows a top view of the drive unit of Figure 26, and Figures 28b to 28f respectively show different cross-sectional side views along the length of the same drive unit and magnified views of certain portions of those cross-sectional side views;

Figures 29a to 29d show four maximum adjusted positions of the side guide wheels of the drive unit of Figure 26;

Figure 30 shows a plot of positions in the X and Z-axes through which the side guide wheels of the drive unit of Figure 26 can be adjusted;

Figure 31 shows an isometric view of another lite-version of the drive unit of Figure 4, according to a third embodiment;

Figure 32 is a perspective view of a launch and recovery system for vessels, which adopts a plurality of drive units of Figure 31;

5 Figures 33a and 33b show the launch and recovery system of Figure 32 in operation;

Figures 34a to 34d show different views of the drive unit of Figure 31, in which the drive unit is adjusted to recover a first vessel of a specific hull form;

Figures 35a and 35b show recovery of the first vessel using the system of Figure 32, in which each drive unit has been adjusted according to Figure 34;

Figures 36a to 36d show different views of the drive unit of Figure 31, in which the drive unit is adjusted to recover a second vessel of another hull form; and

Figures 37a and 37b show recovery of the second vessel using the system of Figure 32, in which each drive unit has been adjusted according to Figure 36.

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Detailed Description of Preferred Embodiments

Figure 1 shows a perspective view of a launch and/or recovery system 100 (hereinafter system) for vessels (e.g. small boats), which are stored/launched from a mother vessel (not shown), according to first embodiment of the invention. For convenience, the three-dimensional Cartesian coordinate axes (hereinafter 3-D reference axes) 101 are shown on the left side of Figure 1 for reference to aid in understanding of how the system 100 is orientated. The X-axis, Y-axis and Z-axis directions as mentioned hereinafter are made with reference to this 3-D reference axes 101, which is also shown in other drawings, where necessary, for the same purpose. The system 100 comprises an entry guide rollers assembly 102, a plurality of drive units 104a-104f, and a support guide unit 106. In particular, the system 100 is configured to be installed on a ramp platform, such as a stern ramp 200 at the stern of the mother vessel, as shown in Figure 2. Each drive unit 104a-104f includes centrally positioned keel rollers that are hydraulically actuated to move a vessel up or down the stern ramp 200, and the exact number of drive units 104a-104f to be installed on the stern ramp 200 depends on the length of the vessel to be launched or recovered using the system 100. In this embodiment, an exemplary number of drive units 104a-104f to be used for the system 100 are six units.

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Figure 3 shows an apparatus 300 for launching and/or recovering a vessel, in which the apparatus 300 comprises the system 100, the mother vessel, and the stern ramp 200 of the mother vessel. Specifically, the stern ramp 200 has an inclination angle of approximately between 8° to 20° relative to a horizontal plane of a base 301, and in this embodiment the base 301 forms part of the mother vessel (i.e. see the angle indicated as " γ " in Figure 3), and is mounted at the bottom of the stern ramp 200 with a pivotably movable ramp door 202 that is hydraulically elevated up or down using hydraulic cylinders 302 to be fully opened or closed to enable launch/recovery of the vessel, as respectively depicted in Figure 2a and 2b. It is to be understood that when the ramp door 202 is in the fully opened position, the ramp door 202 is in line with the inclined stern ramp 200; in other words, the opened ramp door 202 shares the same inclination angle as the stern ramp 200. The inclination angle of the opened ramp door 202, relative to the horizontal plane of the mother vessel, is indicated as " β " in Figure 3, and thus the value of " β " is accordingly equivalent to that of " γ ". Therefore, the opened ramp door 202 forms a substantially continuous inclined surface with the stern ramp 202 in that specific arrangement.

Particularly, in this embodiment, the value of the inclination angle " γ " is about 15° . It is to be appreciated that if the stern ramp 200 is configured to be at a fairly steep inclination angle (i.e. greater than 20°), larger pull-up forces (defined in magnitude) from the drive units 104a-104f need to be generated in order to overcome the effects of gravity for moving a vessel up the steeper inclined stern ramp 200, as will be apparent to a skilled person. However, if the inclination of the stern ramp 200 is configured to be more gentle, in terms of being at an angle of approximately between 8° to 20° (which in this case is about 15°), comparatively smaller pull-up forces are required in order to move the vessel along the stern ramp 200, even after when the vessel is no longer submerged in the waters (i.e. no further provision of self-thrusts from the vessel at this stage of the recovery process), as opposed to having a stern ramp 200 which is more steeply arranged.

The hydraulic cylinders 302 are installed on a drive unit platform 304 of the stern ramp 200. Water drainage outlets (not shown) are respectively arranged on the left and right side at the base of the drive unit platform 304 for draining of any water carried by a vessel recovered from the sea. Further, fenders 306 are also

mounted at the side walls of the stern to prevent the vessel from contacting with the hull of the mother vessel during launch or recovery operations. In addition, the drive unit platform 304 has an indented hydraulic piping channel 308, which is used to run hydraulic hoses and piping of hydraulic motors (not shown) for actuating the drive units 104a-104f. Another water drainage outlet (not shown) is also similarly arranged within the hydraulic piping channel 308 for draining of the water carried by the vessel. It is to be appreciated that adjustment of positions of the drive units 104a-104f in the Y-axis direction does not cause the hydraulic hoses to be entangled with each other that will result in system failure of the system 100. Further, there is also a drain channel 310 at the base of the stern ramp 200 for discharging water carried by the hull of a vessel as the vessel advances up the stern ramp 200 during recovery.

The entry guide rollers assembly 102 is installed near the base of the ramp door 202, followed by first and second drive units 104a, 104b, serially arranged in that order in a direction leading towards the stern ramp 200. More specifically, the entry guide rollers assembly 102 is located near the entrance of the stern ramp 200 for helping to align and guide the vessel which is advancing towards the ramp door 202 to be recovered. For accessibility reasons when the ramp door 202 is fully closed, the first drive unit 104a has a bevel gear assembly 108 arranged adjacent thereto, which is used for adjusting the first drive unit 104a. Specifically, when the ramp door 202 is elevated in the closed position, the first drive unit 104a is about 3 metres from the part of the ramp door 200 that connects to the stern ramp 200, which is thus beyond reach of an operator of normal height when adjustments need to be made to the first drive unit 104a. Therefore, the bevel gear assembly 108 conveniently enables the operator to adjust the first drive unit 104a through the turning motion imparted by the bevel gear assembly 108 during adjustment is necessary.

The remaining drive units 104b-104f are then linearly arranged, one after another, along the drive unit platform 304 of the stern ramp 200, and the arrangement is terminated with the support guide unit 106 located near the top of the stern ramp 200. The role of the support guiding unit 106 is to stop the vessel from advancing beyond an intended point on the stern ramp 200 of the mother vessel. It is to be highlighted that the second drive unit 104b and the

remaining drive units 104b-104f each has an adjustable device configured in the form of a pair of (first and second) worm gear assemblies 312a, 312b arranged adjacent thereto, located by the side of each drive unit 104b-104f. It is also to be appreciated that the support guide unit 106 and drive units 104a-104f are arranged to be spaced apart from each other by a predefined distance. According to this embodiment, the first and second drive units 104a, 104b are horizontally separated by a distance of 1000mm, while the remaining drive units 104c-104f are adjustable in the Y-axis direction to be separated from each other by a minimum distance of 400mm to a maximum of 1000mm, based on requirements of a specific application. This adjustability feature of the remaining drive units 104c-104f will be elaborated in later parts of the description.

Figures 4, 5 and 6 respectively show an isometric view, a side view and an exploded view of one of the drive units 104a-104f. For the sake of brevity, the reference numeral 104 will be used hereinafter (unless otherwise explicitly stated) to represent a single drive unit 104 when making independent reference thereto. Each drive unit 104 comprises a powered drive assembly 1042 (i.e. comprising the keel rollers), and a side guide wheel adjustment assembly 1044, which are arranged on a drive unit base 606. In this instance, the length and width of the drive unit base 606 are respectively approximately 2840mm and 1130mm. Specifically, the powered drive assembly 1042 is formed of three centre keel rollers that are linearly arranged along the width of the drive unit base 606. For ease of description hereinafter, the reference numerals 1042a, 1042b, 1042c are respectively used to refer to (in sequential order) a first, a second and a third centre keel roller of the three centre keel rollers, and not to be confused with the reference numeral 1042 which is only used to refer to the powered drive assembly 1042 as a whole. The second centre keel roller 1042b is interleaved between the first and third centre keel rollers 1042a, 1042c. Furthermore, the first centre keel roller 1042a is arranged to be spaced from the third centre keel roller 1042c by a length of approximately 1420mm (which is the distance between the respective longitudinal axes of the first and third centre keel roller 1042a, 1042c). It is to be appreciated that each centre keel roller 1042a, 1042b, 1042c is arranged transverse to the width of the drive unit base 606.

Each centre keel roller 1042a, 1042b, 1042c is formed from two halves that are coated with a material to form appropriate tread patterns on the surfaces of the centre keel roller 1042a, 1042b, 1042c, and each half resembles a truncated cone (i.e. the apex portion is removed). In addition, each centre keel roller 5 1042a, 1042b, 1042c has a length of about 500mm, and a diameter of approximately 220mm, at the widest section of each half (i.e. at the base of the truncated cone). Importantly, the material adopted for coating is to be characterised with a coefficient of friction (COF) of "0.5", under wet conditions, to ensure there is sufficient friction generated to pull a vessel up the stern ramp 10 200 during a recovery operation. In this embodiment, the material used is sea water resistance rubber, such as butyl rubber. The two halves are joined at the line of truncation of each cone. Thus, each centre keel roller 1042a, 1042b, 1042c has a shape that tapers towards the centre of the roller. Moreover, it is to be appreciated that the tapered portion of each centre keel roller 1042a, 1042b, 15 1042c is appropriately shaped to generally fit with the shape of the centre keel of vessels, in order to provide more contact surfaces for enabling a vessel (in concern) to be efficiently moved (and transferred) long the stern ramp 200 for launch/recovery. Further, the second centre keel roller 1042b is arranged to be free-rolling (on its longitudinal axis), while the first and third centre keel rollers 20 1042a, 1042c are individually driven (or actuated) by respective hydraulic motors 608 (which are operated at the same speed) to rotate at the longitudinal axis. Configuring the first and third centre keel rollers 1042a, 1042c provides operational redundancy to guard against motorised failure. It is to be highlighted that in event of any motorised failure of the hydraulic motors 608, the first and 25 third centre keel rollers 1042a, 1042c are still rotatably operable. The second centre keel roller 1042b is particularly arranged to be free-rolling configuration because the driving forces generated by the first and third centre keel rollers 1042a, 1042c are considered sufficient to move the vessel up/down the stern ramp 200 during operation. Additionally, by not configuring the second centre 30 keel roller 1042b to be hydraulically driven allows an overall weight of the system 100 to be reduced since another hydraulic motor 608 need not be installed to drive the corresponding second centre keel roller 1042b of each drive unit 104a-14f in the system 100.

Further, from Figure 5, it can be appreciated that the second centre keel roller 1042b is mounted to the drive unit base 606, and approximately equally spaced from the first and third centre keel rollers 1042a, 1042c. Specifically, the positioning of the second centre keel roller 1042b serve the purposes of: (a) preventing the bow of the vessel from contacting sections of the stern ramp 200 located between the first and third centre keel rollers 1042a, 1042c as the vessel moves up/down the stern ramp 200, and (b) providing a small gradual recess for the vessel to climb up to the third centre keel roller 1042c, via a rotational motion that is effected when the vessel is in corresponding sequential contact with the first, second and third centre keel rollers 1024a, 1042b, 1024c. This is important because the propulsion of the (to be recovered) vessel is gradually reduced since the drive force initially required to move (and roll) the vessel up the ramp door 202 is progressively supplemented, and eventually replaced by the pull-up forces of the first and third centre keel rollers 1042a, 1042c. Indeed, this configuration thus helps to move and roll the vessel up the stern ramp 200 more effectively for recovery.

The side guide wheel adjustment assembly 1044 adopts a "double adjustable" system, and essentially comprises two identical sections each having a rectangular guide wheel frame 602, and each section is arranged on a respective side of the drive unit 104, respectively located adjacent to the powered drive assembly 1042. That is, the powered drive assembly 1042 is thus interleaved between the two identical sections of the side guide wheel adjustment assembly 1044. Each guide wheel frame 602 houses two free-rolling side guide wheels 604 (which are axially coupled thereto using respective guide wheel pins 601), and arranged side-by-side to each other. Each side guide wheel 604 has a diameter of approximately 430mm. The circumferential sides of the side guide wheels 604 rotate and come into contact with the hull of a vessel that moves along on the system 100. Each guide wheel frame 602 is also pivotably mounted at an angle to the drive unit base 606 (with related mechanisms to be described below) for adjustability, which forms the foundation on which the drive unit 104 is assembled. It will be apparent that each section of the side guide wheel assembly 1042 (i.e. guide wheel frame 602) is movably adjustable relative to the powered drive assembly 1042 to adaptively support a

shaped section of the hull of the vessel, which is resting on the system 100 (for launch or has been recovered).

As afore mentioned, the drive unit 104 has a symmetrical configuration on both
5 sides of the powered drive assembly 1042. Particularly, on each side of the
drive unit 104, there is the guide wheel frame 602 with the two axially mounted
free-rolling side guide wheels 604 for supporting the hull of a (recovered/to be
launched) vessel. The guide wheel frame 602 is pivotably connected to a first
10 slider 612 used for angularly adjusting the side guide wheel adjustment
assembly 1044 via the guide wheel frame 602. The first slider 612 is arranged
transverse to the drive unit base 606, and also slidably mounted thereto, in that
the first slider 612 is adjustable to linearly move along the length of the drive unit
base 606 by sliding along via two guide rods 616 that are mounted on opposite
15 sides, along the length of the drive unit base 606. Specifically, two associated
through holes are provided within at the opposing ends of the first slider 612 to
enable the respective guide rods 616 to be inserted and accordingly allow the
first slider 612 to be slidably adjusted along the drive unit base 606. The length
of each guide rod 616 is substantially as long as the drive unit base 606. Wear
20 pads 618, which slide along on respective longitudinal base grooves 619 formed
on the drive unit base 606, are inserted underneath the first slider 612 to prevent
wear and tear thereon during adjustment of the side guide wheel assembly 1044.
Specifically, the base grooves 619 are arranged on the respective opposite sides
along the length of the drive unit base 606 (i.e. the base grooves 619 run
parallel to the guide rods 616).

25 On the other hand, the guide wheel frame 602 is also further pivotably
connected, at middle portions of the width of the guide wheel frame 602, to a
second slider 614 via two respective frame supports 610 (i.e. auxiliary arms).
Each frame support 610 has a fixed configured length. It is thus apparent that
30 the respective frame supports 610 are pivotably connected to both the second
slider 614 as well as the guide wheel frame 602. Further, the second slider 614
is also arranged transverse to the drive unit base 606, and slidably mounted to
the drive unit base 606 via the two guide rods 616, identical to the arrangement
of the first slider 612, as afore described. Wear pads 618 are also inserted
35 underneath the second slider 614 for the same afore described purpose as in the

first slider 612. It is to be appreciated that the second slider 614 is also used, in conjunction with the first slider 612, for angularly adjusting the side guide wheel adjustment assembly 1044 (which consequently causes the guide wheel frames 602 and associated side guide wheels 604 to move). In particular, each guide wheel frame 602 draws out a longitudinal section of a cylinder, the longitudinal section having a vertical axis orthogonal to the longitudinal axis of the drive unit base 606, as the same guide wheel frame 602 is caused to move by adjustment of the first and second sliders 612, 614. Further, the longitudinal axes of the first and second sliders 612, 614 intersect the longitudinal axis of the drive unit base 606 as the first and second sliders 612, 614 slidably move along the two guide rods 616. It is also to be understood that the first slider 612 is arranged, at one face, to be adjacent to the powered drive assembly 1042, while there is the second slider 614 being arranged adjacent to the first slider 612 at an opposing face thereof.

Now with reference to the first slider 612, there is provided a set of first bushes 620 which are mounted within associated through holes provided in the first slider 612 to enable the first slider 612 to easily slide through the guide rods 616 during adjustment of the side guide wheel adjustment assembly 1044. Particularly, each of the set of first bushes 620 is shaped in the form of a truncated tube, and encapsulates the respective guide rods 616 to prevent wear and tear during the course of operation, as the first slider 612 moves on the drive unit base 606. Similarly an identical set of second bushes 622 are mounted within associated through holes provided in the second slider 614 for the same very purpose, as the second slider 614 moves on the drive unit base 606. More details about the arrangement of the sets of first and second bushes 620, 622 within the first and second sliders 612, 614 will be described in Figure 8. To aid in the restoration of the first and second sliders 612, 614 to their respective original resting positions after release of an adjustment configuration of the side guide wheel adjustment assembly 1044, springs 624 are installed (together with the set of first and second bushes 620, 622 respectively) as inserted partially within the first and second sliders 612, 614, and specifically, each spring 624 in the configured state is transversally arranged relative to the longitudinal axes of the first and second sliders 612, 614.

Further, a pair of clockwise lead screws 630 (with reciprocating clockwise lead screw nuts 632) are installed (within the pair of first and second sliders 612, 614 located on the right side of the drive unit base 606) for translating clockwise rotating motion into linear motion during adjustment of the side guide wheel assembly 1044, while a pair of counter-clockwise lead screws 634 (with reciprocating counter-clockwise lead screw nuts 636) are also installed (within another pair of the first and second sliders 612, 614 located on the left side of the drive unit base 606) for translating counter-clockwise rotating motion into linear motion during adjustment of the side guide wheel assembly 1044. In nautical terms, the right side refers to the starboard side and left side refers to the port side, and such references are to be as understood hereinafter. For the clockwise lead screws 630, it is to be appreciated that the associated screw threads are formed in a clockwise manner, and vice-versa for the counter-clockwise lead screws 634. The clockwise lead screws 630 and counter-clockwise lead screws 634 are longitudinal members and substantially of circular-shaped cross-sectional. For ease of description hereinafter, the clockwise lead screws 630, clockwise lead screw nuts 632, counter-clockwise lead screws 634, and counter-clockwise lead screw nuts 636) are termed as the lead screw set. In other words, the combination of those clockwise and anti-clockwise turning motions imparted by the lead screw set causes the associated pairs of first and second sliders 612, 614 to linearly move on the drive unit base 606 via the guide rods 616.

Centre joints 640 are then installed to connect together the respective clockwise and counter-clockwise lead screws 630, 634 arranged on the opposing left and right sides of the drive unit base 606. Each centre joint 640 is specifically formed as a longitudinal member. In effect, two units of centre joints 640 are thus required to connect together the respective clockwise and counter-clockwise lead screws 630, 634 in the drive unit 104. A clockwise and a counter-clockwise lead screw 630, 634 that are connected to a centre joint 640 together form a sliders moving assembly, and thus there are two sets of sliders moving assemblies as can be appreciated. Each sliders moving assembly is respectively configured to move all of the first sliders 612 or second sliders 614. Specifically, the clockwise lead screws 630 on the right side are connected to the corresponding counter-clockwise lead screws 634 on the left side. Therefore,

through the connection via the centre joints 640, the clockwise and counter-clockwise lead screws 630, 634 are collectively rotated, and the rotating motions are then translated into corresponding linear motions to consequently move the respective pairs of first and second sliders 612, 614 simultaneously on the drive unit base 606. As the first and second sliders 612, 614 move, the respective guide wheel frames 602 and frame supports 610 are accordingly adjusted, thus changing the positions of the side guide wheels 604.

The first and second worm gear assemblies 312a, 312b respectively translates the motion required to turn the corresponding sliders moving assembly during adjustment of the associated side guide wheel assembly 1044. More particularly, the first worm gear assembly 312a controls adjustment of the pair of first sliders 612 on both sides of the drive unit 104, while the second worm gear assembly 312b controls adjustment of the pair of second sliders 614 on both sides of the drive unit 104. It is importantly to be understood that turning adjustment of the lead screw set is effected by turning the first and second worm gear assemblies 312a, 312b with an adjustment key set 644 (i.e. see Figure 11). Further, in order to allow the drive unit 104 to be adjustably movable in the Y-axis direction (refer to 3-D reference axes 101 on the side of Figure 6), if necessary, two adjustment slots 638 are each conveniently provided on respective lateral edges of the drive unit base 606 along the width, which are also used to securely lock the drive unit 104 at a desired fixed position on the stern ramp 200.

Turning to Figures 7a-7f, magnified views of certain parts of the drive unit 104 are shown, depicting more details about the respective parts of the drive unit 1045 as afore described in the preceding two paragraphs. It is to be understood and appreciated that the respective magnified views for a side of the drive unit 104 are accordingly identical for the other opposite side of the drive unit 104, which as afore described is arranged with a symmetrical configuration on both sides. Figure 7a is a magnified view of the counter-clockwise lead screw nuts 636 arranged as inserted into an associated through hole provided in the second slider 614, and translates the rotating motion of the counter-clockwise lead screws 634 into linear motion along the X-axis direction for the second slider 614, that is arranged on the left side of the drive unit base 606. The same effect is to be understood in respect of the clockwise lead screws 630 and clockwise lead

screw nuts 632 for moving the second slider 614 that is arranged on the right side of the drive unit base 606, Figure 7b is correspondingly a magnified view of the counter-clockwise lead screw nuts 636 arranged as inserted into an associated through hole provided in the first slider 612, and translates the rotating motion of the counter-clockwise lead screws 634 into linear motion along the X-axis direction for the first slider 612, that is arranged on the left side of the drive unit base 606. The same effect is to be understood in respect of the clockwise lead screws 630 and clockwise lead screw nuts 632 for moving the first slider 612 that is arranged on the right side of the drive unit base 606.

Indeed, it is thus apparent that the first and second sliders 612, 614 arranged on the right side of the drive unit base 606 are linearly moved by the clockwise rotating motion imparted by the clockwise lead screws 630, while the first and second sliders 612, 614 arranged on the left side of the drive unit base 606 is moved by the counter-clockwise rotating motion imparted by the counter-clockwise lead screws 634. It is to be understood that this arrangement can be configured in a reverse manner as necessary; that is the first and second sliders 612, 614 arranged on the right side of the drive unit base 606 is moved using the counter-clockwise lead screws 634, whereas the first and second sliders 612, 614 arranged on the left side of the drive unit base 606 is moved using the clockwise lead screws 630.

Figure 7c is magnified view of the wear pad 618, as shown inserted underneath the first slider 612 (and understood to be similar for the second slider 614), which is arranged to slide on the base groove 619 as the first slider 612 is adjustably moved. Figure 7d shows a magnified view of the spring 624 inserted inside the guide rod 616 of the first slider 612, in which one half of the spring 624 is inserted into the first slider 612 with the other half exposed in between a spacing between the first slider 612 and the neighbouring second slider 614. This configuration will be elaborated in Figure 8. Figure 7e is then a magnified view of the set of second bushes 622 inserted inside the through hole provided within the second slider 614 and encapsulating the guide rod 616 running therethrough. Lastly, Figure 7f is a magnified view of a lever lock 642 for securing the drive unit 104 to the drive unit platform 304 of the stern ramp 200 through an appropriate point on the adjustment slot 638.

Figure 8 correspondingly shows a magnified view of the spring 624 inserted within the first slider 612. More particularly as shown, one half of the spring 624 is contained within the through hole provided in the first slider 612, while the other half is exposed in the spacing that separates the first slider 612 and the neighbouring second slider 614. On the other hand, a unit of the set of first bushes 620 is contained within the remaining half of the same through hole provided in the first slider 612 that is not occupied by the spring 624, and encapsulates the guide rod 616. A stopper (not shown), such as a washer, separates the spring 624 from the unit of set of first bushes 620 within the through hole. It is also to be appreciated that the set of second bushes 622 however occupies the full length of the associated through holes provided within the second slider 614, since no such springs 624 are arranged to be attached to the second slider 614. It is to be understood that during adjustment of the side guide wheel assembly 1044 to support a vessel of a specific hull form, the first and second sliders 612, 614 moves towards each other and consequently the spring 624 is compressed when the first and second sliders 612, 614 moves sufficiently close to contact each other. Subsequently, when the side guide wheel assembly 1044 is no longer supporting the hull of the vessel, separation of the first and second sliders 612, 614 away from each other is effected by the resilient forces of the spring 624 to push the first and second sliders 612, 614 back to their original respective resting positions.

Referring now to Figure 9, a unit of the worm gear assembly 312a, 312b is shown. In particular, Figures 9a to 9e are respectively a perspective view, a top view, a front side view, a back side view, and an exploded view of the worm gear assembly 312a, 312b. Each worm gear assembly 312a, 312b comprises a worm gear set casing 902, a worm 904, a worm wheel 906, and a square key slot 908 removably screwed to the worm wheel 906. Specifically, the casing 902 houses the worm gear (i.e. the worm 904, worm wheel 906, and square key slot 908), and is formed with an inner hollow space, both the casing 902 and hollow space being of a generally rectangular shape. Further, it will be appreciated that the casing 902 is formed with appropriate slots and holes at the sides for accommodating the worm 904, worm wheel 906, and square key slot 908. In assembled form (i.e. see Figure 9a), the worm 904 and worm wheel 906 are

housed within the casing 902 and connected as a gear assembly, while the square key slot 908 is located external to the casing 902 but coupled (i.e. screwed) to the worm wheel 906. To adjust the side guide wheel assembly 1044 to accommodate and support a particular hull form, the adjustment key set 644 is plugged into an insert of the square key slot 908 to turn the worm gear assembly 312a, 312b. The adjustment key 644 has a square tip end which is receivable by the square key slot 908. On turning the adjustment key 644, the equivalent rotational motion of the turning action is then imparted to the square key slot 908 and worm wheel 906, and correspondingly, this rotational motion is converted into linear motion by the connected worm 904 causing adjustment of the side guide wheel assembly 1044.

Figure 10 shows the bevel gear assembly 108, which comprises two identical (first and second) bevel gear casings 1002a, 1002b, first set of straight bevel gears 1004a, 1006a, and second set of straight bevel gears 1004b, 1006b, a pair of (first and second) drive shafts 1008a, 1008b, and (first and second) square key slots implements 1010a, 1010b. Particularly, Figures 10a to 10e are respectively a perspective view, a bottom view, a side view in respect of the length, a side view in respect of the width, and an exploded view of the bevel gear assembly 108. The first bevel gear casing 1002a houses both the first and second sets of straight bevel gears 1004a, 1006a, 1004b, 1006b, while the second bevel gear casing 1002b houses the (first and second) square key slots implements 1010a, 1010b. In assembled form (i.e. see Figures 10a and 10b), the second set of straight bevel gears 1004b, 1006b (in the first bevel gear casing 1002a) is coupled via an attached turning member 1005b to the corresponding second drive shaft 1008b which is in turn coupled to the second square key slot implement 1010b (which is provided with an associated square key slot exposed on an upper surface of in the second bevel gear casing 1002b to facilitate easy adjustment using the adjustment key 644). In particular, the square key slot receives the square tip end of the adjustment key 644 for turning the second drive shaft 1008b, similar to the operation of the worm gear assemblies 312a, 312b. The first set of straight bevel gears 1004a, 1006a (in the first bevel gear casing 1002a) is then coupled to the corresponding first drive shaft 1008a which is in turn coupled to the first square key slot implement 1010a via an attached turning member 1005a (which is also provided with an

associated square key slot that is identical to that of the second square key slot implement 1010b for the same purpose). In other words, the two bevel gear casings 1002a, 1002b are thus coupled together via the pair of drive shafts 1008a, 1008b to provide adjustment for the first drive unit 104a.

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It is to be appreciated the first and second set of straight bevel gears 1004a, 1006a, 1004b, 1006b each has two tooth-bearing gears that engage each other, and are orthogonally arranged relative to one another, and are generally conically shaped; it will be appreciated that each tooth-bearing gear moves in an
10 opposite direction to the other (i.e. clockwise for one, and counter-clockwise for the other). Otherwise the configurations of the first and second sets of straight bevel gears 1004a, 1006a, 1004b, 1006b are generally similar to equivalent bevel gears known in the art, and thus for the sake of brevity, will not be elaborated further herein. More specifically, one of the tooth-bearing gears
15 1004a of the first set of straight bevel gears 1004a, 1006b is connected to the first drive shaft 1008a, while the other associated orthogonal tooth-bearing gear 1006a is then connected to the first worm gear assembly 312a. Therefore, turning of the first square key slot implement 1010a correspondingly causes turning of the attached turning member 1005a, which effectively rotates the
20 connected first drive shaft 1008a on its axis. As the respective gears of the first set of straight bevel gears 1004a, 1006a orthogonally engage each other, the rotation of the first drive shaft 1008a turns the gear 1004a connected thereto, and thus accordingly causes the orthogonally engaged gear 1006a that is directly connected to the clockwise lead screw 630 to rotate as well. As a result,
25 this then turns the associated clockwise lead screw 630. The afore described turning operations using the first set of straight bevel gears 1004a, 1006a is illustrated in Figure 10f. In effect, the axes of the clockwise lead screw 630 and the first drive shaft 1008a intersect, and thus the direction of rotation drive of the first drive shaft 1008a is changed by 90° to be imparted to the clockwise lead
30 screw 630, allowing adjustments to be made to the first sliders 612 (arranged on the starboard and port side of the first drive unit 104a).

On the other hand, one of the tooth-bearing gears 1004b of the second set of straight bevel gears 1004b, 1006b is connected to the second drive shaft 1008b,
35 while the other associated orthogonal tooth-bearing gear 1006b is connected to

the second worm gear assembly 312b. Therefore, turning of the second square key slot implement 1010b correspondingly causes turning of the attached turning member 1005b, which effectively rotates the connected second drive shaft 1008b on its axis. As the respective gears of the second set of straight bevel gears 1004b, 1006b orthogonally engage each other, the rotation of the second drive shaft 1008b turns the gear 1004b connected thereto, and thus accordingly causes the orthogonally engaged gear 1006b that is connected to the clockwise lead screw 630 to rotate as well. As a result, this associatively turns the corresponding clockwise lead screw 630. The afore described turning operations using the second set of straight bevel gears 1004b, 1006b is also illustrated in Figure 10f. That is, the axes of the clockwise lead screw 630 and the second drive shaft 1008b intersect, and hence the direction of rotation drive of the second drive shaft 1008b is consequently changed by 90° to be imparted to the clockwise lead screw 630, allowing adjustments to be made to the second sliders 614 (arranged on the starboard and port side of the first drive unit 104a).

Figure 11 accordingly shows the adjustment key 644 used to make adjustments to the bevel gear assembly 108 (i.e. by insertion into the square key slot 1010). As afore described, the bevel gear assembly 108 is installed only at the first drive unit 104a for accessibility reasons. In adjusting the side guide wheels 604, the force required for imparting the rotating motion is transmitted via the bevel gear assembly 108, which is easily and conveniently reachable by the operator as the second bevel gear casing 1002b, which has the square key slots 1010, of the bevel gear assembly 108 is arranged adjacent to the second drive unit 104b, which is at a height reachable by an average man, when the ramp door 202 is in the closed position. The same method of operation is to be understood in applying the adjustment key 644 to the worm gear assembly 312a, 312b.

Figures 12a and 12b respectively show a side view along the length and a top view of the drive unit 104. In particular, the top view of Figure 12b is a cross-sectional view of Figure 12a taken along line A-A. Further, Figures 12c and 12d show corresponding magnified views of two side sections of the top view of Figure 12b. Specifically, Figure 12c depicts the detailed layout of the double-adjustable system of the drive unit 104, viewed from the starboard (i.e. right) side of the mother vessel, whereas Figure 12d depicts the corresponding

detailed layout of the double- adjustable system, viewed from the port (i.e. left) side of the mother vessel.

Figure 13a shows the top view of the drive unit 104, while Figures 13b to 13d are respective cross-sectional views taken transverse to the length of the drive unit 104, which are clearly indicated in Figure 13a by the corresponding reference numerals "1", "2" and "3" (but will be respectively referenced as "Section 1", "Section 2" and "Section 3" hereinafter for ease of description). "Section 3" is located closest to the powered drive assembly 1042, while "Section 1" is located farthest, with "Section 2" interleaved between "Section 1" and "Section 3". "Section 1" (i.e. Figure 13b) shows the cross-sectional view of the second slider 614 with the associated clockwise lead screws 630, clockwise lead screw nuts 632, guide rods 616, and second set of bushes 622. "Section 2" (i.e. Figure 13c) then shows the cross-sectional view of the first slider 612 with the associated springs 624, and guide rods 616. "Section 3" (i.e. Figure 13d) shows the cross-sectional view of the first slider 612 with the associated clockwise lead screws 630, clockwise lead screw nuts 632, guide rods 616, wear pads 618 and first set of bushes 620.

Figures 14a to 14d show four different maximum adjusted positions of the side guide wheel adjustment assembly 1044 to depict operation of the "double adjustable" system proposed for each drive unit 104. For the purpose of this set of drawings, the following definitions are provided: "Q" is the horizontal distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 arranged on the port side to the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 arranged on the starboard side. This distance "Q" is respectively labelled as "Q1" to "Q4" in Figures 14a to 14d. "P" is an angle defined between the rectangular guide wheel frame 602 and the drive unit base 606. This angle "P" is respectively labelled as "P1" to "P4" in Figures 14a to 14d. Further, "H" is the vertical distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 (arranged on the starboard or port side) to the drive unit base 606. This distance "H" is labelled as "H1" to "H4" in Figures 14a to 14d.

In Figure 14a, "Q1" is 2140mm, "H1" is 580mm, and "P1" is 5°. In Figure 14b, "Q2" is 1670mm, "H2" is 1020mm, and "P2" varies from 0° to a maximum of 40°. For Figure 14c, "Q3" is 2410mm, "H3" is 1020mm, and "P3" also varies from 0° to a maximum of 40°. In Figure 14d, "Q4" is 3650mm, "H4" is 580mm, and "P2" varies from 0° to a maximum of 5°. Thus, the "double adjustable" system enables the side guide wheel assemblies 1044 to be adjusted in both the X-axis and Z-axis directions. As a result, the amount of working area for supporting the hull of a vessel by the drive unit 104 is increased and any protrusion or attachment under the hull that lie along the guided paths are avoided through use of the "double adjustable" system.

As afore described, the "double adjustable" system involves use of two symmetrical sections of the side guide wheel adjustment assembly 1044 that are each arranged on the respective sides of the powered drive assembly 1042. Each section comprises corresponding the first and second sliders 612, 614. To ensure that the first and second sliders 612, 614 are moving together in parallel with one another (i.e. with the same degree of movement) for an operation, all the first and second sliders 612, 614 are slidably moved on the common pair of two guide rods 616. The respective two clockwise lead screws 630, which are arranged parallel to each other, on the starboard side, also run through the first and second sliders 612, 614. Each clockwise lead screw 630 controls movement of the first slider 612 or second slider 614, depending where the associated clockwise lead screw nuts 632 are mounted (refer to Figure 12c). Similarly, on the port side, movement of the first and second sliders 612, 614 are controlled by two counter-clockwise lead screws 634. Each of the two counter-clockwise lead screws 634 controls the first slider 612 or second slider 614, depending where the associated counter-clockwise lead screw nuts 636 are mounted (refer to Figure 12d).

Figure 15 shows a plot 1500 of positions in the X and Z-axes through which a side guide wheel 604 (of the side guide wheels assembly 1044) can be adjusted, but is equally applicable to the remaining side guide wheels 604 of the drive unit 104. Specifically, the side guide wheels assembly 1044 can be angularly adjusted using the "double adjustable" system, which involves use of the first and second sliders 612, 614, clockwise lead screws 630 and screw nuts 632,

and counter-clockwise lead screws 634 and screw nuts 636, to move to any position within an trapezoid-like area 1502 as defined on the plot 1500. The boundaries of the area 1502 are delimited by points "A", "B", "C" and "D". With reference to a data table 1504 provided to the left side of the plot 1500, the coordinates of the points "A", "B", "C" and "D", as specified in a coordinate format: "[X, Z]", are respectively "[900, 445]", "[730, 780]", "[1010, 780]" and "[1460, 455]". It is thereby highlighted that the metric units of the data points in the data table 1504 are in millimetres ("mm").

It is to be appreciated that in real-life operations, prior to making the necessary adjustments to the respective side guide wheel assemblies 1044 of each drive units 104a-104f, an operator of the system 100 first compares the cross-sectional contour of the hull, of a vessel to be recovered or launched, with the plot 1500 of Figure 15 to determine how the side guide wheels 604 can be allocated (i.e. moved) to a suitable position to avoid any protrusions or attachments on the hull of the vessel before commencing any operations. It will also be apparent that each drive units 104a-104f is to be differently adjusted since each drive units 104a-104f supports a different shaped section of the hull. Then with reference from the determined position allocations of the side guide wheels 604, positions of the first and second sliders 612, 614 required to be adjusted accordingly are consequently determinable. In other words, the system 100 is required to be pre-adjusted in order to subsequently support the hull of a vessel that is to be launched from or recovered to.

Figures 16a and 16b respectively show back views 1600 of two hulls 1602, 1604 of different forms (i.e. shapes) that are supported by the system 100. In particular, Figures 16a and 16b illustrate how the side guide wheel assemblies 1044 (of the drive units 104a-104f) are adjusted to conform to the different shaped sections of the respective hulls 1602, 1604.

Referring to the support guide unit 106, which is installed near the top of the stern ramp 200, Figures 17a and 17b respectively show an isometric view and an exploded view of the support guide unit 106 of the system 100, while Figures 18a to 18c correspondingly show the respective top view, front view and side view of the similar support guide unit 106. It is to be appreciated that the

support guide unit 106 has a guide wheel assembly 1700 which is symmetrically formed on both sides of a support guide unit base 1702, as will be evident from the isometric view of Figure 17a. The support guide unit base 1702 has an approximate length of 2840mm, and a width of 300mm. The primary purpose of the support guide unit 106 is for supporting the bow head portion of a hull of a vessel that is resting on the system 100. Besides that, the support guide unit 106 also serves as a vessel stopper to prevent the vessel from advancing beyond an intended point on the stern ramp 200 during recovery. It will be understood that the basic working mechanism for the support guide unit 106 is substantially similar as the drive unit 104, with an exception that the support guide unit 106 lacks the powered drive assembly 1042.

Particularly, the support guide unit 106 comprises the support guide unit base 1702, which on each side there is a free-rolling side guide wheel 604 for supporting a vessel by the bow head portion of the hull. The side guide wheel 604 is axially coupled to a guide wheel arm 1704 via a guide wheel pin 601, and there is also a guide wheel arm support 1706 for pivotably supporting the guide wheel arm 1704 through a middle section thereof to the support guide unit base 1702. The circumferential sides of the side guide wheel 604 rotate and come into contact with the bow head portion of the hull of the vessel. It is also to be noted that the guide wheel arm 1704 is additionally pivotably coupled at one end to the support guide unit base 1702. The guide wheel arm support 1706 is in turn pivotably connected to a slider 1708 which is able to slide along the counter-clockwise lead screw 634 (or the clockwise lead screw 630 for the opposite side of the support guide unit 106) for adjusting the guide wheel arm 1704. The slider 1708 is formed to resemble a block and is provided with wear pads 618 underneath to prevent wear and tear of the guide wheel assembly 1700 when performing adjustment, and the wear pads 618 slide on grooves 619 (centrally formed along the length of the support guide unit base 1702) during the adjustment.

Further, an associated counter-clockwise lead screw nut 636 is provided for the counter-clockwise lead screw 634, and likewise a clockwise lead screw nut 632 is provided for the clockwise lead screw 630. The counter-clockwise lead screw 634 translates counter clockwise rotating motion into linear motion during

adjustment, and likewise the clockwise lead screw 630 translates clockwise rotating motion into linear motion. The clockwise and counter-clockwise lead screws 630, 634 are then connected together by the centre joint 640. The support guide unit 106 also has a worm gear assembly 312c for translating the motion required to rotate the clockwise and counter-clockwise lead screws 630, 634 during adjustment. The worm gear assembly 312c is installed on the side, at the width of the support guide unit 106.

For the purpose of Figure 18, the following definitions are provided: "A" is the horizontal distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1700 arranged on the port side to the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1700 arranged on the starboard side. "B" is an angle defined between the guide wheel arm 1704 and the support guide unit base 1702. Further, "C" is the vertical distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1700 to the support guide unit base 1702. Particularly, the guide wheel arm 1704 is adjustable to move through an angle that varies between 12° to 80° (i.e. the range of values for "B"). When the value of "B" is 12° , "A" and "C" take the values of 2130mm and 560mm respectively. On the other hand, when the value of "B" is 80° , "A" and "C" consequently take the values of 550mm and 1110mm respectively.

That said it will be appreciated from the foregoing description that besides not being configured with a powered drive assembly 1042, the support guide unit 106 is also different from the drive unit 104 in terms of having only one set of clockwise lead screws 630, counter-clockwise lead screws 634, lead screw centre joints 640, and slider 312c. Thus, the support guide unit 106 has only one degree of available adjustment.

Accordingly, Figures 19a and 19b depict respective front views 1900 of how the corresponding bow heads of the two similar hulls 1602, 1604 of Figures 16a and 16b are supported by the support guide unit 106. Importantly, it is to be appreciated that in order to be useful for real-life applications, the system 100 needs to be configured with an adjustable arrangement for accommodating vessels of different hull forms. Indeed, the required adjustable arrangement

feature of the system 100 is realised through the side guide wheel adjustment assemblies 1044. It will further be appreciated that an arrangement of any of the side guide wheel assemblies 1044 after adjustment is generally of a symmetrical V-shape which is in conformance with the hull structure of typical vessels, as understood by skilled persons.

Figures 20a shows the entry guide rollers assembly 102, which is installed near the base of the ramp door 202, together with the first and second drive units 104a, 104b as afore described with reference to Figure 1. The other remaining Figures 20b to 20e respectively show an isometric view, a top view, a front view, and a side view of the entry guide rollers assembly 102. The entry guide rollers assembly 102 comprises four sets of entry guide roller 202, which is axially mounted to an entry guide rod base 204 (that is in turn coupled to the ramp door 202), in order for the entry guide roller 202 to be able to be freely movable on its axis. It is to be appreciated that a pair of the entry guide rollers 202 (forming a first series of entry rollers 206a) are arranged in an opposing configuration and being spaced closer to each other than the remaining pair of entry guide rollers 202 (forming a second series of entry rollers 206b), which are also arranged in an opposing configuration. In other words, the entry guide rollers 202 in the second series of entry rollers 206b are arranged to be spaced wider apart. Specifically, the entry guide rollers 202 of the first series of entry rollers 206a are separated by a distance of approximately 1400mm, while those of the second series of entry rollers 206b are separated by a distance of approximately 1900mm. Moreover, the first series of entry rollers 206a is (horizontally) spaced from the second series of entry rollers 206b by about 530mm. In addition, the first series of entry rollers 206a is spaced from the first drive unit 104a by a distance of approximately 500mm. Furthermore, the combined height of an entry guide roller 202 attached to the entry guide rod base 204, in the first series of entry rollers 206a, is approximately 550mm, while the corresponding in the second series of entry rollers 206b is about 750mm.

Particularly, the second series of entry rollers 206b is arranged to be near the edge of the ramp door, and then followed by the first series of entry rollers 206a (in the direction leading towards the stern ramp 200). Additionally, each entry guide rod base 204 (with the entry guide roller 202) is mounted with respect to

the ramp door 202 at an angle to inwardly face the opposing entry guide rod base 204. Particularly, this angle is defined to be 75°. in this embodiment. Accordingly in this arrangement, the first and second series of entry rollers 206a, 206b form two rows that are approximately parallel to the width of the ramp door 202, from the top view as depicted in Figure 10c.

Prior to a vessel recovery operation, the plurality of drive units 104a-104f, and the support guide unit 106 are each adjusted independently to subsequently support respective shaped sections of the hull of a vessel to be recovered. It is therefore apparent that, in using the system 100, prior knowledge of the shape and contours of the hull of a vessel to be recovered is required. Then during the recovery operation, the first and second series of entry rollers 206a, 206b are all fully submerged in water as the ramp door 202 is elevated to an open position. With reference to Figure 21a, by a side view, as the (floating) vessel 2100 advances towards the stern ramp 200 (and thus also the ramp door 202), the vessel 2100 does not need to be perfectly aligned with the centreline of the stern ramp 200, with the use of the proposed system 100. Specifically, when the bottom section of the bow of the vessel 2100 comes into contact with the entry guide rollers assembly 102, and the immediately adjacent first and second series of entry rollers 206a, 206b (which collectively provides guiding to the vessel 2100 as it approaches the ramp door 202), the vessel 2100 is able to subsequently align itself with respect to the centreline of the stern ramp 200 through its own propulsion pushing force. It is to be appreciated that the propulsion of the vessel 2100 is to be maintained until the vessel 2100 is able to be supported on the first and second drive units 104a, 104b as shown in Figure 21b. Indeed, in this manner, the power required to move the vessel 2100 up the stern ramp 200 is progressively transferred from the propulsion of the vessel 2100 to the driving power generated by the drive units 104a-104f of the system 100.

Figures 22a and 22b show how the drive units 104a-104f are adjustable in a longitudinal Y-axis direction along the stern ramp 200. Particularly, each drive unit 104a-104f, as afore described, is provided with a pair of adjustment slots 638 on respective sides, at the width (of the drive unit base 606) of the drive unit 104a-104f for this purpose. To movably adjust each drive unit 104a-104f, the

associated lever locks 642 are unlocked (i.e. released) and the corresponding drive unit 104a-104f is then adjustably moved in the longitudinal Y-axis direction within the limit of the length of the channel defined by the adjustment slots 638 to a desired position. When that is done, the associated lever locks 642 are then re-locked so that the corresponding drive unit 104a-104f is secured in place on the stern ramp 200.

To illustrate by way of an example, before adjustment, Figure 22a shows that the system 100 is installed on a stern ramp 200, with the first and second drive units 104a, 104b being spaced apart by a gap of "X" unit (e.g. mm) and the remaining drive units 104c-104f being spaced apart from a neighbouring drive unit by a gap of "Y" unit (e.g. mm). The second drive unit 104b is spaced from the adjacent drive unit 104c installed on the stern ramp 200 by a gap of "R" unit, and this gap "R" remains fixed throughout. After adjustment (as effected according to the method described in the preceding paragraph) as shown in Figure 22b, the spacing between the first and second drive units 104a, 104b remains unchanged at a gap of "X" unit (e.g. mm). On the other hand, the remaining drive units 104c-104f are now being spaced apart from a neighbouring drive unit by a gap of "Z" unit (e.g. mm), in which "Z" is greater than "Y". In this example, the values of "X", "Y", "Z" and "R" are 1000mm, 400mm, 1000mm, and 1300mm respectively. It is to be appreciated that the first and second drive units 104a, 104b are fixated to the ramp door 202 while the number of drive units mounted on the drive unit platform 304 of the stern ramp 200 can be increased or reduced depending on the overall loading requirement and length of the vessel to be recovered/launched. As the drive unit 104 is devised to be easily portable, spare drive units 104 can therefore be kept on the mother vessel and be installed on the stern ramp 200 as necessary. It will also be apparent that if it is desired to move the remaining drive units 104c-104f closer together, then "Z" is less than "Y" as will be easily understood by skilled persons, also dependent on the length and weight of a vessel to be recovered. Furthermore, it is also to be appreciated that the drive units 104c-104f installed on the stern ramp 200 are not required to be uniformly distributed; that is, the gap of "Z" or "Y" unit can take on different values between a pair of configured drive units 104.

Figure 23 is an isometric view of the vessel 2100 of Figure 21, after being recovered, and supported on the system 100. In conjunction, Figures 24a and 24b respectively show a side view and a bottom view of the same recovered vessel 2100 resting on the system 100. It can be seen from Figure 24a that the adjustable side guide wheels 604 symmetrically arranged on both sides of the drive units 104a-104f form and provide a guided path 2400 for the vessel 2100 to progressively slide (i.e. move) up and down the stern ramp 200, depending whether it is desired to recovery or launch the vessel 2100. Figure 25 shows yet another isometric view of the recovered vessel 2100 of Figure 21 resting on the system 100, illustrated together with the ramp door 202 and stern ramp 200.

Further embodiments of the invention will be described hereinafter. For the sake of brevity, description of like elements, functionalities and operations that are common between the embodiments are not repeated; reference will instead be made to similar parts of the relevant embodiment(s).

According to a second embodiment, Figure 26 shows an isometric view of a lite-version of the equivalent drive unit 104 of Figure 4, which will hereinafter be termed as lite drive unit 260 for ease of description. For more details on the structure of the lite drive unit 260, Figure 27 provides an exploded view for corresponding illustration. It will be apparent from a visual comparison between the drive unit 104 of Figure 4 and the lite drive unit 260 that the latter also adopts the same "double adjustable" system, in terms of being configured with the same powered drive assembly 1042 and side guide wheel adjustment assembly 1044. Specifically, the lite drive unit 260 is devised for prototyping and testing purposes for the system 100. As such, lite drive unit 260 is therefore lighter and cheaper to fabricate due to having a simpler design compared to the drive unit 104 of Figure 4. Further, it is to be appreciated from the isometric view of Figure 26 that the lite drive unit 260 is also symmetrically formed on both sides of a lite drive unit base 262 with respect to the powered drive assembly 1042, in terms of the side guide wheel adjustment assembly 1044 having a similar section on respective sides of the powered drive assembly 1042. For convenience, the lite drive unit base 262 is further formed with handles 263 on the sides, at the width of the lite drive unit base 262 to allow the lite drive unit 260 to be easily carried by hand if necessary.

As mentioned, the lite drive unit 260 is comprises the lite drive unit base 262, which on each side there is the guide wheel frame 602 and two free-rolling side guide wheels 604, axially mounted to the guide wheel frame 602 via respective guide wheel pins 601. Further, the circumferential sides of the side guide wheels 604 rotate and come into contact with, to support the hull of a vessel (to be recovered/launched) that moves along on the system 100. The guide wheel frame 602 is pivotably connected to a first slider 264 used for angularly adjusting the side guide wheel adjustment assembly 1044 via the guide wheel frame 602. The first slider 264 is detachably secured to the lite drive unit base 262 by respective locking pins 266. On the other hand, the guide wheel frame 602 is also further pivotably connected, at middle portions of the width of the guide wheel frame 602, to a second slider 268 via two respective frame supports 610, which is individually of a fixed length. In other words, the respective frame supports 610 are hence pivotably connected to both the second slider 268 as well as the guide wheel frame 602. The second slider 268 is in turn detachably secured to the lite drive unit base 262 by respective locking pins 266. It is to be appreciated that the second slider 268 is also used for angularly adjusting the side guide wheel adjustment assembly 1044 via the frame supports 610. In addition, the first and second sliders 264, 268 are arranged transverse to the length of the lite drive unit base 262.

Moreover, the lite drive unit base 262 is formed with a set of side adjustment holes 270 and a set of top alignment holes 272. More specifically, the set of side adjustment holes 270 includes a row of equally spaced holes appropriately arranged on the lateral sides of the lite drive unit base 262 for adjustment of the first slider 264 or second slider 268. Adjustment is made by first moving the first slider 264 or second slider 268 to the desired positions on the lite drive unit base 262 and then securing using the locking pins 266. Similarly, the set of top alignment holes 272 includes a row of equally spaced holes appropriately arranged on the top sides of the lite drive unit base 262 used for alignment during adjustment of the first slider 264 or second slider 268. Alignment of the first slider 264 or second slider 268 is made using alignment pins 274 (see Figure 28). As will be appreciated, the set of side adjustment holes 270 are arranged orthogonal to the set of top alignment holes 272.

As afore mentioned, the lite drive unit 260 is installed with the powered drive assembly 1042 which comprises three centre keel rollers 1042a, 1042b, 1042c (first, second and third respectively) that are similar to the ones adopted in the drive unit of Figure 4, and accordingly the same reference numerals will be used as such to refer to them hereinafter. The second centre keel roller 1042b is disposed between the first and third centre keel rollers 1042a, 1042c, which are hydraulic-driven by the respective hydraulic motors 608 attached thereto, whereas the second centre keel roller 1042c is in a free-rolling configuration. The lite drive unit base 262 is also formed with adjustment slots 638 on respective edges, at the width of the lite drive unit base 262 in order to facilitate position adjustment of the lite drive unit 260 in the Y-axis direction. Securing of the lite drive unit 260 to the drive unit platform 304 of the stern ramp 200 via the adjustment slot 638 is accomplished using respective lever locks 642, similar to the arrangement as afore described for the drive unit 104 of Figure 4.

From the foregoing description, it will be apparent that adjustment of the side guide wheel adjustment assembly 1044 of the lite drive unit 260 is different from the drive unit 104 of Figure 4. Particularly, adjustment of the side guide wheel adjustment assembly 1044 of the lite drive unit 260 is achieved by using: (1). the first slider 264 and second slider 268, (2). the set of side adjustment holes 270 formed on the lite drive unit base 262, and (3). the locking pins 266 to lock and secure the first slider 264 and second slider 268 to their desired positions after adjustment.

Figure 28a shows a top view of the lite drive unit 260, while Figures 28b and 28c depict respective cross-sectional views of the lite drive unit 260 taken transverse to the length thereof, which are clearly indicated in Figure 28a by the corresponding reference numerals "4", and "5" (but will be respectively referenced as "Section 4", and "Section 5" hereinafter for ease of description). "Section 5" is located closest to the powered drive assembly 1042, while "Section 4" is located further away, and outer to "Section 5". Figures 28d and 28e are corresponding magnified views of portions of "Section 5" (i.e. Figures 28b) and "Section 4" (i.e. Figures 28c) respectively.

Particularly, "Section 4" (i.e. Figure 28c) shows the second slider 268 locked and secured to the lite drive unit base 262 by means of the locking pin 266 inserted into a hole of the set of side adjustment holes 270. In addition, "Section 4" also shows the alignment pin 274 aligned and inserted into a hole of the set of top alignment holes 272. "Section 5" (i.e. Figure 28b) then shows the first slider 264 locked and secured to the lite drive unit base 262 by means of the locking pin 266 inserted into a hole of the set of side adjustment holes 270. "Section 5" further depicts the alignment pin 49 aligned and inserted into a hole of the set of top alignment holes 272.

It is to be appreciated from Figures 28a to 28f that by manually adjusting the positions of the first and second sliders 264, 268 by securing at desired positions on the lite drive unit base 262 through insertion of the locking pin 266 into a hole of the set of side adjustment holes 270, positions of the side guide wheel 604 can consequently be adjusted. Further, the alignment pin 274, which is shown in Figure 28f is used to align the first and second sliders 264, 268, is arranged to be inserted perpendicularly into an associated hole of the set of top alignment holes 272. This allows the first and second sliders 264, 268 only to be adjusted parallel to the X-axis direction. It is to be further understood that the alignment pin 274 has a chamfered head to allow easy manual insertion into a hole of the set of top alignment holes 272 during adjustment.

Figures 29a to 29d show four different maximum adjusted positions of the side guide wheel adjustment assembly 1044 of the lite drive unit 260, which similar to the drive unit 104 of Figure 4, to depict the operation of the "double adjustable" system. For the purpose of this set of drawings, the following definitions are provided: "G" is the distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 arranged on the port side to the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 arranged on the starboard side. This distance "G" is respectively labelled as "G1" to "G4" in Figures 29a to 29d. "K" is an angle defined between the rectangular guide wheel frame 602 and the lite drive unit base 262. This angle "K" is respectively labelled as "K1" to "K4" in Figures 29a to 29d. Further, "V" is the vertical distance measured from the upper most tip of a side guide wheel 604 of the side guide wheels assembly 1044 (arranged on the starboard or port side)

to the lite drive unit base 262. This distance "V" is labelled as "V1" to "V4" in Figures 29a to 29d.

5 In Figure 29a, "G1" is 2040mm, "V1" is 490mm, and "K1" is 12°. In Figure 29b, "G2" is 1640mm, "V2" is 830mm, and "K2" is 40°. For Figure 29c, "G3" is 2200mm, "V3" is 830mm, and "K3" is 40°. In Figure 29d, "G4" is 3300mm, "V4" is 490mm, and "K4" is 12°. It is to be appreciated from Figures 29a to 29d that when the angle "K" is adjusted to be the same, the height "V" as arranged will also be the same (e.g. see Figures 29a and 29d).

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Figure 30 shows a plot 3000 of positions in the X and Z-axes through which a side guide wheel 604 of the side guide wheel adjustment assembly 1044 of the lite drive unit 260 can be adjusted, but is equally applicable to the remaining side guide wheels 604. Specifically, the side guide wheel assembly 1044 is
15 angularly adjusted using the "double adjustable" system, which involves use of the first and second sliders 264, 268, the set of side adjustment holes 270, and locking pins 266, to move the associated side guide wheel 604 to an approximate, nearest position adjacent to or at a data point within an area 3002 (formed by a scattered array of data points) defined on the plot 3000. That is, in
20 some instances, the positioning of the side guide wheels 604 of the lite drive unit 260 to support an associated shaped section of the hull is only a best-fit adjustment. It will also be apparent from the plot 3000 that the boundaries of the area 3002 are approximately delimited by data points: "A", "B", "C" and "D". With reference to a data table 3004 provided to the left side of the plot 3000, the
25 dimensional positions of the various data points in the scattered array are shown. Further, the coordinates of the points "A", "B", "C" and "D", as specified in a coordinate format: "[X, Z]", are respectively "[900, 445]", "[730, 780]", "[1010, 780]" and "[1460, 455]", as listed in the data table 3004. It is highlighted that the metric units of the data points in the data table 3004 are in millimetres ("mm").

30

It will be apparent that in operation, each drive unit 260, when installed on the system 100, is to be differently adjusted since each drive unit 260 supports a different shaped section of the hull. It is therefore to be appreciated that, prior to adjustment, an operator of the system 100 compares the cross-sectional
35 contour of the hull, of a vessel to be launched or recovered, with the plot 3000 of

Figure 30 to determine how the side guide wheels 604 of each lite drive unit 260 are to be adjusted to an appropriate position corresponding to the nearest data point (as defined in the scattered array of the area 3002) on the plot 3000 that will allow the side guide wheels 604 to support the associated contour structure of the hull, without encountering any protrusions and attachments that might be present on the exterior surface of the hull. Since the configured adjustability of the lite drive unit 260 is such that the side guide wheels 604 can only be moved to an approximate/nearest position (i.e. best-fit) indicated by a data point (as shown in the area 3002 of the plot 3000 of Figure 30), in some instances, there will inevitably be a (small) gap between the adjusted side guide wheels 604 of a specific lite drive unit 260 that are supporting the particular section of the hull, as the side guide wheels 604 cannot be adjusted to exactly fit the shape of that particular section of the hull. Indeed, the lite drive unit 260 is thus not as precise and accurate as the drive unit 104 of Figure 4. Nonetheless, to ensure optimal operation of the system 100, which uses the lite drive units 260, to launch/recover vessels, the corresponding spacing between respective holes in the set of side adjustment holes 270 formed on the lite drive unit base 262 is customisable by prior determination of the hull forms of the associated vessels to which the system 100 is to be applied on.

According to a third embodiment, Figure 31 shows an isometric view of another lite-version of the equivalent drive unit 104 of Figure 4, which will hereinafter be termed as e-lite drive unit 3100 for ease of description, as the e-lite drive unit 3100 is extremely simplified in comparison to the drive unit 104 of Figure 4 or the lite drive unit 260 of Figure 26. In terms of basic configuration, the e-lite drive unit 3100 is largely similar to the drive unit 104 of Figure 4 or the lite drive unit 260 of Figure 26. Particularly, the e-lite drive unit 3100 comprises a drive unit base 3102, on which the powered drive assembly 1042 is centrally arranged and to each side of the powered drive assembly 1042, there is a side guide wheel adjustment assembly 1044. In this instance, the side guide wheel adjustment assembly 1044 is configured with a guide wheel frame 3104 which is fixedly attached at the top portion with two side guide wheels 604 that are spaced apart from each other. That is, the side guide wheels 604 are not in a free-rolling arrangement.

Further, the guide wheel frame 3104 is detachably secured at its base portion to the drive unit base 3102 via mounting points (not shown) that are formed on both sides, along the length, of the drive unit base 3102. Moreover, the guide wheel frame 3104 is also configured to be pivotably movable inwardly towards the
5 powered drive assembly 1042 during adjustment of the side guide wheel adjustment assembly 1044. It is also to be appreciated that the guide wheel frame 3104 is angularly arranged relative to the drive unit base 3102. Indeed, a (variable) angle is defined between the guide wheel frame 3104 and the drive unit base 3102. More specifically, an auxiliary arm member 3106 is pivotably
10 attached to the guide wheel frame 3104, and is arranged to be latched releasably to the mounting points on the drive unit base 3102. The auxiliary arm member 3106 is thus formed of a sufficient length to serve the afore-described purpose. Moving the auxiliary arm member 3106 to latch to a different mounting point thus allows the side guide wheel adjustment assembly 1044 to be adjusted
15 accordingly.

In other words, as the guide wheel frame 3104 is adjusted by moving the auxiliary arm member 3106 to be latched to a desired mounting point, such that the angle defined in between the drive unit base 3102 grows increasingly acute,
20 the auxiliary arm member 3106 consequently moves closer to the powered drive assembly 1042. This is also to be understood in a vice-versa manner; as the adjusted angle increases, the auxiliary arm member 3106 moves away from the powered drive assembly 1042. Additionally, when adjusting the side guide wheel adjustment assembly 1044, the guide wheel frame 3104 can also be
25 detached (as afore mentioned) and be re-attached to a desired inward mounting point on the drive unit base 3102, in conjunction with latching the auxiliary arm member 3106 to different mounting points (i.e. see Figures 35 and 37 for example illustrations).

30 Figure 32 then depict a perspective view of a launch and recovery system 3200 (hereinafter second system), which is largely similar to the system 100 of Figure 1, except that the drive units 104a-104f (of Figure 4) have been substituted by a plurality of e-lite drive units 3100a-3100f, and the support guide unit 106 (of Figure 17) has been replaced by an equivalent lite support guide unit 3202. In
35 particular, the lite support guide unit 3202 is simpler in construction to the

support guide unit 106 (of Figure 17), in that the lite support guide unit 3202 is formed of a V-shape main member, which is truncated at the apex, and two side guide wheels 604 are each (fixedly) mounted at the respective tips of the arms of the truncated V-shape member. However, unlike the support guide unit 106, the lite support guide unit 3202 is not configured to be adjustable in any manner. It is to be appreciated that, in this embodiment, the number of e-lite drive units 3100a-3100f installed in the second system 3200 is six units. It will also be apparent that the manner of operation of the second system 3200 for launch/recovery of vessels is largely the same as the system 100 of Figure 1, and thus will not be repeated in detail again. To illustrate an example of usage, Figures 33a and 33b depict the second system 3200 in operation for recovering a vessel 3400.

Figures 34a to 34d show different views of the e-lite drive unit 3100 which has been adjusted to recover a first vessel 3600 (shown in Figure 35a) of a specific hull form. Specifically, Figure 34a to 34d respectively shows a front view, a top view, a side view, and a perspective view of the adjusted e-lite drive unit 3100. While Figures 35a to 35d show only one e-lite drive unit 3100, it will be understood that each of the e-lite drive units 3100a-3100f of the second system 3200 is to be independently adjusted to subsequently support respective shaped sections of the hull of the first vessel 3600. It is also apparent that prior knowledge of the shape and contours of the hull of the first vessel 3600 is required. Figures 35a and 35b then correspondingly show recovery of the first vessel 3600 using the second system 3200, in which each of the e-lite drive units 3100a-3100f has been prior adjusted in an appropriate manner in accordance with the configuration shown in Figure 34.

On the other hand, Figures 36a to 36d show different views of the e-lite drive unit 3100 which has been adjusted to recover a second vessel 3800 (shown in Figure 37a) of another specific hull form. Specifically, Figure 36a to 36d respectively shows a front view, a top view, a side view, and a perspective view of the adjusted e-lite drive unit 3100. Similarly, while Figures 36a to 36d show only one e-lite drive unit 3100, it will be understood that each of the e-lite drive units 3100a-3100f of the second system 3200 is to be independently adjusted to subsequently support respective shaped sections of the hull of the second

vessel 3800. As it is apparent, prior knowledge of the shape and contours of the hull of the second vessel 3800 is required. Figures 37a and 37b correspondingly show recovery of the second vessel 3800 using the second system 3200, in which each of the e-lite drive units 3100a-3100f has been prior adjusted in an appropriate manner in accordance with the configuration shown in Figure 36.

In summary, the proposed system 100 comprises three sub-assemblies namely: (1). the drive units 104a-104f (or lite drive units 260 or e-lite drive units 3100) for rolling (i.e. moving) a vessel up or down the stern ramp 200 with the associated hydraulic-driven centre keel rollers 1042a, 1042b, 1042c, (2). the entry guide rollers assembly 102, and (3). the support guiding unit 106 to prevent the vessel from advancing beyond an intended point of the stern ramp 200 during recovery. During launching, the ramp door 202 is lowered down (into an open position) by means of hydraulic cylinders 302 installed on the drive unit platform 304 of the stern ramp 200. The hydraulic-driven centre keel rollers 1042a, 1042b, 1042c of the drive units 104a-104f are activated to rotate slowly, which allows the vessel to progressively be released from the mother vessel into the sea smoothly. Beneficially, this minimises the risk of damage to the stern of the vessel as compared to conventional systems, which allows the vessel to roll down the stern ramp 200 freely.

Further, prior to recovery, the side guide wheel adjustment assemblies 1044 of the system 100 may first individually be pre-adjusted to approximately suit respective shaped sections of the hull structure of a vessel to be recovered, if such knowledge is available before hand. The appropriate adjustments may include: (1). adjusting the side guide wheels 604 in the X-axis direction by means of the gear and lead screw assemblies, and (2). adjusting the line of serially arranged drive units 104a-104f in the Y-axis direction along the drive unit platform 304. After this one-time manual pre-adjustment is completed, the ramp door 202 is subsequently lowered to allow the vessel to enter. As the vessel advances up the stern ramp 200 via the ramp door 202, the entry guide roller assembly 102, which is incorporated at the entrance of the ramp door 202, aligns and guides the vessel up the stern ramp 200.

Subsequently, the respective hydraulic-driven centre-keel rollers 1042a, 1042b, 1042c in the drive units 104a-104f are operated to rotate (in a reverse direction), thus providing the pull-up force required for rolling the vessel up the stern ramp 200. Throughout this recovery process, no human intervention is required to
5 guide or roll the vessel up the stern ramp 200. Hence, the proposed system 100 is applicable for recovering or launching unmanned boats such as unmanned-surface-vehicles (USVs), while also being suitable for launch/recovery of recreational marine crafts or other types of manned vessels. In addition, the proposed system 100 can also easily be retrofitted to any mother vessel, as long
10 as the mother vessel is arranged with an inclined launch/recovery platform. Besides, the system 100 is advantageously arranged with features that flexibly allow the system 100 to adaptively be adjustable for easy launch/recover of vessels of different hull forms, without the need to specially install custom-made systems for launching/recovering a vessel of a particular hull form. Moreover,
15 from a mother vessel, the proposed system 100 advantageously allows vessels of approximately 11 metres long, and weighing about 12 tons, to be rapidly launched or recovered, at a sea state of level-3 (based on the sea state codes standard set out by the World Meteorological Organization). Thus adoption of the proposed system 100 may importantly mitigate risk of launch/recovery
20 personnel falling into the sea due to strong tidal waves, eliminates the undesirable need to hook up a winch to recover/launch a vessel under strong sea conditions, and avoid incurring other related safety issues (e.g. risk of injury to the hands of the launch/recovery personnel when hooking up the winch), which then beneficially improves the overall safety of vessel launch/recovery
25 operations, as opposed to using conventional methods/systems.

Additionally, it is to be appreciated that in conventional systems, any protrusions or attachments that may be attached under the hull of vessels can affect the launch and recovery when the associated vessel is being transferred along a
30 guided path provided by the conventional systems, thus potentially causing instability during movement of the vessel on the systems. This consequently affects the overall efficiency of launch and recovery operations. This is because conventional systems typically comprise passive rollers that are arranged in fixed positions or rollers with just one degree of adjustment. As such,
35 conventional systems are not flexibly adjustable in order for the supporting

members to avoid those protrusions or attachments under the hull, and yet also to be able to provide a close fit support for the hull of the vessel, according to the required manner of operation. This problem is however advantageously overcome by the proposed system 100, according to afore described
5 embodiments of the invention, through use of the "double adjustable" system (i.e. effected via the two degrees of adjustability of the side guide wheel adjustment assemblies 1044).

The described embodiments should not however be construed as limitative. For
10 example, instead of manually adjusting (by turning) the bevel gear assembly 108 or the worm gear assembly 312a, 312b using the adjustment key 644 as afore described with reference to Figure 11, the turning motion may alternatively be automatically effected by configuring the adjustable device to be in the form of electric or hydraulic motors which are (remotely or wirelessly) controlled via
15 computerised systems in order to achieve full automation of the entire system 100. In such an instance, the first drive unit 104a may then be configured with the worm gear assembly 312a, 312b, instead of the bevel gear assembly 108. In addition, according to another alternative embodiment, it is to be understood that the first and second drive units 104a, 104b may be adjustable to move
20 within predefined confines of the ramp door 202 in the Y-axis direction, instead of being fixated thereto in predetermined positions. Yet further, the powered drive assembly 1042 may instead be driven using other types of actuation means, not necessary hydraulic motors 608. Particularly, the other types of actuation means to be deployed are to be suitable for operation in wet conditions,
25 as it will be apparent that the drive units 104a-104f inevitably will come into contact with seawater during launch/recovery of a vessel. This is especially so for the first and second drive units 104a, 104b, which are installed on the ramp door 202, as they 104a, 104b may be submerged below the water line when the ramp door 202 is deployed in the open position (i.e. see Figure 21b). Further,
30 each frame support 610 may also optionally be arranged to be in the form of a piston arm, turnbuckle arm or any type of functionally equivalent member for greater flexible operation, instead of having a fixed length.

Additionally, the second centre keel roller 1042b of the powered drive assembly
35 1042 of each drive unit 104c to 104f, installed on the drive unit platform 304 of

the stern ramp 200, may be removable, leaving only the first and third centre keel rollers 1042a, 1042c as originally configured. This thus advantageously reduces the overall weight of the proposed system 100, and thus the loading the system 100 imposes on the mother vessel. It also provides for easier
5 maintenance of the system 100 in the long term. Yet further, the powered drive assembly 1042 are alternatively not fitted with the respective hydraulic motors 608 to drive the first and third centre keel rollers 1042a, 1042c; that is the first and third centre keel rollers 1042a, 1042c may be configured to be free-rolling instead. In this embodiment, launch/recovery of a vessel via the proposed
10 system up/down the stern ramp 200 is to be performed using a winch system or any suitable equivalent pulling system, or launch and recovery device as understood to be possible by a skilled person. Further optionally, with reference to the first embodiment, the winch system or equivalent pulling means may also be used to launch/recover the vessel, except that the respective configured
15 hydraulic motors 608 of each drive unit 104a-104f are switched off, and not in active use. That is, the vessel is pulled up/down using the winch system or equivalent pulling means instead. It is to be appreciated that in this instance, application of the proposed system 100 is then suitable only for launching or retrieving manned vessels, but not USVs. Alternatively, the winch system or
20 equivalent pulling means is to be used in conjunction with the respective powered drive assemblies 1042 of each drive unit 104a-104f. Yet additionally, each centre keel roller 1042a, 1042b, 1042c may be coated using a silicon-based material, that are also water resistance, to form suitable tread patterns on the surface of each centre keel roller 1042a, 1042b, 1042c. It is also to be
25 understood that the proposed system 100 (which in this instance is modified with the centre keel rollers of the associated powered drive assembly 1042 of each drive unit 104a-104f configured in a free-rolling arrangement, instead of being hydraulically powered) or only the "double adjustable" side guide wheel adjustment assembly 1044 may appropriately be installed on boat trailers, and to
30 be used in conjunction with a winch system or any suitable equivalent pulling system, or launch and recovery device as understood to be possible by a skilled person. Therefore, it is to be appreciated and understood that in this instance, each drive unit 104a-104f may instead be termed as a support unit 104a-104f, since the pulling force is generated by the winch system instead of the powered
35 drive assembly 1042 of each support unit 104a-104f. Further alternatively, the

proposed system 100 may instead be installed on a stern ramp 200 that is arranged to be pivotably movable at any desired angle relative to the horizontal plane of the mother vessel, as opposed to the stern ramp 200 being arranged at a fixed angle relative to the horizontal plane of the mother vessel, as afore
5 described in the first embodiment. In this instance, the stern ramp 200 is then additionally configured with further hydraulic pumps and actuators (not shown) that are necessary to effect the desired angular movement of the stern ramp 200, in which the specific manner of operation will be understood by a skilled person, and thus not elaborated herein.

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Alternatively, the proposed system 100, instead of being installed on the stern ramp 200 of the mother vessel, may first be installed on an independent horizontal platform, which is then subsequently arranged to be mounted inclined at an angle relative to an intermediate base, which is separate from the mother
15 vessel, and specifically configured for this purpose. The angle of inclination may be approximately between 8° to 20°, as afore described. The entire arrangement of the intermediate base and the inclined platform (on which the system 100 is installed) is then mounted into an insert space of the mother vessel, in which the insert space is configured to be sufficiently large to accept
20 the entire arrangement of the intermediate base and inclined platform. Indeed, the apparatus 300 for launching and recovering a vessel in this instance therefore comprises only the proposed system 100, and the independent horizontal platform.

25 While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary, and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practising the claimed
30 invention.

Claims

1. An apparatus for launching and/or recovering a vessel, comprising:
a launch and recovery platform, the platform being configured to be inclined relative to a horizontal plane of a base;
5 a plurality of drive units arranged along the platform, each drive unit having a set of guide members for supporting the vessel's hull; and
an actuator configured to actuate the respective sets of guide members to cause the hull to move progressively along the platform for launch or recovery of the vessel.
10
2. The apparatus of claim 1, wherein the base is configured to be mounted to a mother vessel.
3. The apparatus of claim 1, further comprising a mother vessel, wherein the
15 base is part of the mother vessel.
4. The apparatus of any preceding claim, further comprising a pulling means which is removably attachable to the vessel to, in conjunction with the respective sets of actuated guide members, progressively move the vessel along the
20 inclined platform.
5. The apparatus of claim 4, wherein the pulling means includes a winch.
6. The apparatus of claim 1, wherein each drive unit comprises a plurality of
25 side support members for supporting sides of the hull, the plurality of side support members being arranged adjacent to the set of guide members.
7. The apparatus of claim 6, wherein each side support member includes at least one roller for engaging with the sides of the hull, and a pivotable arm
30 configured to support the at least one roller, the at least one roller configured to be free-rolling.
8. The apparatus of claim 7, wherein a position of the pivotable arm is adjustable to enable the at least one roller to engage with a respective shaped
35 section of the hull.

9. The apparatus of claim 8, wherein the pivotable arm is adjustable to move between an angle of 5° and 40° relative to the base of each drive unit.

5 10. The apparatus of claim 8 or 9, further comprising an auxiliary arm for adjusting the position of the pivotable arm, the auxiliary arm being of a fixed length.

10 11. The apparatus of any preceding claim, wherein each drive unit further comprising at least one free-rolling guide member which is interleaved between the set of guide members.

15 12. The apparatus of any preceding claim, further comprising a set of entry guide rollers for guiding the vessel towards or away from at least some of the plurality of drive units to enable recovery or launch of the vessel, and is arranged to be near a first end of the platform at which the vessel is launched or recovered.

20 13. The apparatus of claim 12, further comprising a support guide unit being adjustable to support the bow section of the hull, and is arranged to be near an end of the platform opposite to the first end.

25 14. The apparatus of claim 13, wherein the support guide unit includes a pivotable arm configured to support at least one roller for engaging with the bow section, and the pivotable arm is adjustable to move between an angle of 12° and 80° relative to the base of the support guide unit.

30 15. The apparatus of any preceding claim, wherein the set of guide members include keel rollers.

16. The apparatus of any preceding claim, wherein the platform is configured to be inclined at an angle of approximately between 8° to 20°.

35 17. A mother vessel for launching and/or recovering a vessel, comprising the apparatus of any preceding claim, wherein the apparatus is installed on a launch

and recovery platform of the mother vessel, the platform being configured to be inclined at an angle of approximately between 8° to 20° relative to a horizontal plane of the mother vessel.

- 5 18. A method for launching and/or recovering a vessel using an apparatus, the apparatus includes a plurality of drive units arranged along a launch and recovery platform, the platform being configured to be inclined relative to a horizontal plane of a base, each drive unit having a set of guide members for supporting the vessel's hull, and an actuator configured to actuate the respective
10 sets of guide members, the method comprises:

operating the actuator to actuate the respective sets of guide members to cause the hull to move progressively along the platform for launch or recovery of the vessel.

- 15 19. The method of claim 18, wherein each drive unit comprises a plurality of side support members for supporting sides of the hull, each side support member includes at least one roller, and a pivotable arm configured to support the at least one roller, further comprises adjusting the pivotable arm to engage the at least one roller with a respective shaped section of the hull.

20

20. The method of claim 18 or 19, wherein the base is configured to be mounted to a mother vessel.

21. The method of claim 18 or 19, further comprises providing a mother
25 vessel, wherein the base is part of the mother vessel.

22. An apparatus for launching and/or recovering a vessel, comprising:
a launch and recovery platform, the platform being inclined relative to a horizontal plane of a base;
30 a plurality of support units arranged along the platform, each support unit having a set of side support guide members which are in an angularly adjustable arrangement with the base of the drive unit for supporting the sides of the vessel's hull; and

launch and recovery device to cause the hull to move progressively along the platform to be supported by the respective sets of adjusted side support guide members for launch or recovery of the vessel.

5 23. The apparatus of claim 22, wherein each side support member includes at least one roller for engaging with the sides of the hull, and a pivotable arm configured to support the at least one roller, the at least one roller configured to be free-rolling.

10 24. The apparatus of claim 23, wherein a position of the pivotable arm is adjustable to enable the at least one roller to engage with a respective shaped section of the hull.

15 25. The apparatus of any of claims 22 to 24, wherein each support unit further comprises a set of guide members which are configured to be free-rolling and arranged adjacent to the set of side support guide members.

26. The apparatus of any of claims 22 to 25, wherein the launch and recovery device includes a winch.

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